Concepts of Measure and Statistical Analysis
Necessary for Mastery of the Science Grade Level Expectations

This document identifies those concepts of measure and statistical analysis articulated in the Grade-Level Expectations for Science and that are expected for mastery on the Missouri Assessment Project Science assessments.

Students should know and be able to:

- identify and apply the appropriate concepts of measure when describing properties of objects and substances,
- identify and use appropriate methods and tools of measure,
- identify and use the correct units of measure for those particular properties, and
- identify and apply the property formula for use when calculating derived measures.

Students will be provided reference sheets listing only formulae for use when calculating derived measures (e.g., work, force, acceleration) in response to constructed-response assessment items.

Teachers are encouraged to include frequent active learning experiences in the curriculum that provide opportunities for student practice and mastery of observation and measurement skills when collecting and analyzing data.

Expected Grade Level for Mastery	CONCEPT	TOOLS	METRIC UNITS with abbreviation	FORMULA
5, 8, 11	Length (Distance)	Metric ruler, meter stick	Meter (m), centimeter (cm), kilometer (km)	Direct measure
5, 8, 11	Mass	Balance (scale)* (*scale alone is not sufficient)	Gram (g), milligram (mg), kilogram (kg)	Direct measure
5, 8, 11	Volume	Graduated cylinder	Liter (L), milliliter (mL), kiloliter (kL)	Direct measure
5, 8, 11	Volume of irregular object	Graduated cylinder	Liter (L), milliliter (mL), kiloliter (kL)	Derived measure by displacement Volume of object = (volume of liquid + object) – (volume of liquid without object)
5, 8, 11	Temperature	Thermometer	degree Celsius (^{o}C)	Direct measure
5, 8, 11	Time	Stopwatch, clock	Second (s)	Direct measure
8, 11	Area of a rectangle	Metric ruler	Square meters (m2)	Area = length x width (A = l x w)
8, 11	Volume of a cube	Metric ruler	Cubic meters (m3) Cubic centimeters (cm3 or cc)	Volume = length x width x height (V = l x w x h)
11	Density	Balance for mass Graduated cylinder for volume (or metric ruler if a cube)	Grams/cubic meters (g / m3)	Density = mass ÷ Volume (D = m ÷ V)

Expected Grade Level for Mastery	CONCEPT	TOOLS	METRIC UNITS with abbreviation	FORMULA
5, 8, 11	Force	Spring scale (*scale alone is not sufficient)	Newton (N)	Direct measure
5 (direct measure only) 8, 11	Weight (Force of Earth's gravity acting on an object)	Spring scale for direct measure OR Balance for mass when deriving quantity	Newton (N) (when derived = kilogram x 9.8 meter/seconds^2)	Direct measure OR Weight (at sea level) = Mass x acceleration of gravity at sea level ($w = m \times 9.8\ m/s^2$)
8, 11	Speed	Stopwatch Metric Ruler	meter/second (m/s)	Speed = distance traveled ÷ time ($v = d \div t$) Average Speed = Total distance traveled ÷ Total time interval
11	Acceleration	Stopwatch Metric ruler	Meters/second/second (m/s/s or m/s^2)	Acceleration = change of velocity ÷ time interval ($a = (v_f - v_s) \div t$)

Expected Grade Level for Mastery	CONCEPT	TOOLS	METRIC UNITS with abbreviation	FORMULA
8, 11	Movement of an object depends on the force applied and its mass (Newton's 2nd Law of Motion)	Balance for mass Spring scale for force Stopwatch & metric ruler for calculating acceleration	meters/second^2 = Newton / kilograms (m/s^2)	Acceleration = net Force ÷ mass (a = F ÷ m)
			Newton = kilograms x meters/second/second (N = kg x m/s^2)	Force = mass x acceleration (F = m x a)
11	Kinetic energy (energy of motion) Potential energy (energy of position) KE + PE = Total energy of a system	Spring scale for force Metric ruler for distance	Joule (J) (may be referred to as Newton . meter when deriving unit)	Energy = Force x distance (E = F x d) KE = ½ mass x speed^2 (KE = ½ m x v^2) $PE_{gravitational}$ = weight x height above surface (PE_{grav} = w x h)
8, 11	Work (transfer of energy through motion)	Spring scale Metric ruler	Joule (J) (may be referred to as Newton . meter when deriving unit)	Work = force x distance (W = F x d)
11	Efficiency	Spring scale and metric ruler to calculate work (F x d)	No unit of measure (units cancel)	Efficiency = Work output ÷ Work input (Efficiency = W_o ÷ W_i)
11	Power	Spring scale Metric ruler Stopwatch	Watts = Joules/second (W = J/s)	Power = Work ÷ time (P = W ÷ t)

Expected Grade Level for Mastery	**CONCEPT**	**TOOLS**	**METRIC UNITS with abbreviation**	**FORMULA**
5 (Concept Introduced) 8, 11 Formulas not assessed directly However, are necessary for mastery of **concept**	Mechanical advantage (Number of times a machine multiples the effort force)	Spring scale	No unit of measure (Units cancel)	Mechanical advantage = $\frac{\text{resistance force of the load}}{\text{effort force}}$ $(MA = F_r \div F_e)$ * May vary for individual simple machines
	Ideal Mechanical Advantage of a lever*	Metric ruler		IMA = $\frac{\text{Length of effort arm}}{\text{Length of resistance arm}}$ $(IMA = L_e \div L_r)$
	Ideal Mechanical Advantage of a Pulley*			IMA = number of ropes supplying an upward support force on the resistance
	Ideal Mechanical Advantage of a Wheel and Axle*	Metric ruler		IMA = radius of wheel ÷ radius of axle $(IMA = r_w \div r_a)$
	Ideal Mechanical Advantage of an Inclined Plane*	Metric ruler		IMA = $\frac{\text{Effort distance}}{\text{Resistance distance}} = \frac{\text{length of slope}}{\text{height of slope}}$ $(IMA = l \div h)$
8, 11	Mean (Average)		Will vary with property measured	Sum of all individual values in a data set ÷ Number of values in the data set
8, 11	Range		Will vary with property measured	Difference between greatest and least values in a data set
11	Percent			Parts out of a hundred, equal parts
11	Ratio		Will vary with property measured	Relationship between two values that have the same unit; proportion